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BOUNDARY CHANGES IN A RURAL-URBAN FRINGE

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BOUNDARY CHANGES IN A RURAL-URBAN FRINGE

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KALEVI RIKKINEN

HELSINKI 1972

Editor:
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1853

Presented 17th December 1971
by Stig Jaatinen and Pentti Yli-Jokipii

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ABSTRACT

The purpose of the study is to examine how changes in boundaries of ownership may be used to illustrate an urban growth zone. The experimental area is Carlton County in northern Minnesota west of Duluth. Boundary changes seem to reflect sensitively changes in a rural-urban fringe. Changes can be noted quickly from maps and are quantitatively measurable. The study of boundaries enables an urban growth zone to be spatially anlysed in terms of small areas, which is often impossible through published census data.

I. INTRODUCTION

A. Purpose of study

Rapid changes occur constantly in the urban-rural continuum of today. By means of census data collected periodically it is possible to analyse the general trends of change, but there are two factors which make elucidation difficult. In the first place information from the census, gathered usually at ten-year intervals, is often out of date and does not enable rapid changes to be explained. In addition, the effects of urbanization are felt in a wide area surrounding the city long before urban settlement arrives there. In the second place regional units in population counts are often too big for study purposes. This is the case in the United States, for instance, where the smallest area for collection of statistical data is usually the township. Collection of data at township level is severely limited, however. More information is available at the level of the county, which is too large a unit for precise study.

The purpose of the study is to present a factor which reflects changes in the growth zone of the city as sensitively as possible. Changes in the boundaries of land ownership have been chosen to represent this factor. To be more exact, the purpose of the study is dual: 1) to classify and analyse boundary changes in a city's immediate sphere of influence during a specific period; 2) to elucidate the possible relationship between types of boundary change and zones of urban growth.

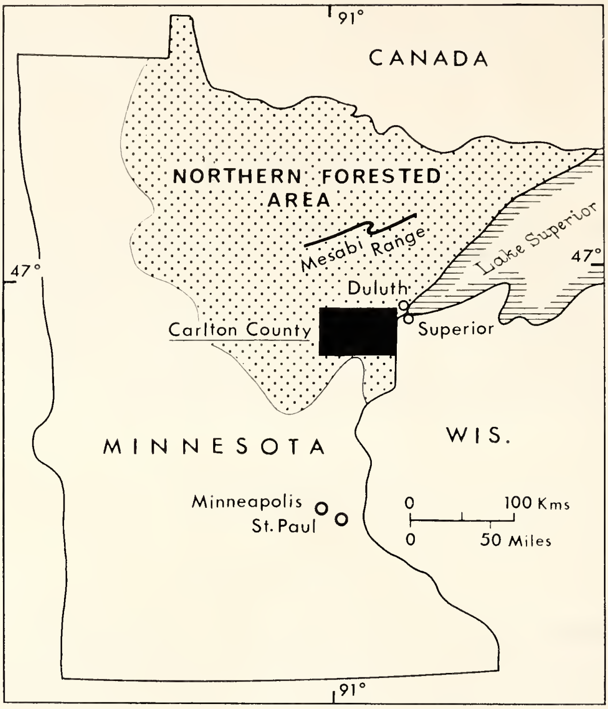

Fig. 1. Location of Carlton County.

B. *Field of study*

The experimental area is Carlton County in northern Minnesota west of Duluth (Figs. 1 and 2, Appendix 1). The eastern boundary of Carlton County is near the city limit of Duluth, and the eastern parts of the county belong closely to the city's growing suburban zone (Fig. 3). The most distant western parts of the county are on the outer boundary of the Duluth commuting area. The location of the field of study is thus highly suitable for an investigation of the present kind. It may also be regarded as an advantage that the circumstances of land division here are in accord with the congressional system of land survey. Land ownership in the county follows a checkerboard pattern quite closely. Also, a good background for study is provided by earlier investigations to explain population development in the area (Rikkinen 1968, Rikkinen & Alanen 1969), and the agricultural settlement of one township (Kalevala) in the county (Rikkinen 1969). These earlier studies have in fact been a source of stimulus and ideas for the present work.

C. *Study material*

Two atlases (Plat Books) of Carlton County from different periods were used as a starting-point:

1) Official Atlas of Carlton County, Minnesota. The Atlas Co., Wyoming, Minnesota, 1957.
2) Triennial Atlas & Plat Book, Carlton County, Minnesota. Rockford Map Publishers, Rockford, Illinois, 1967.

Both atlases show the boundaries of land ownership and the names of landowners. By comparing sketch maps it is possible to analyse changes which have occurred in the boundaries of ownership in the period 1957—67.

II. CLASSIFICATION OF BOUNDARIES

A. *Boundary types based on proprietary relationships*

From the Plat Books which are used as source material it is possible to classify lands into three major categories:

1) Privately owned land.
2) Land owned by companies and agencies.
3) Land owned by county, state or federal authority.

This situation of division into three for 1967 is presented in the land ownership map (Appendix 2). It will be seen that privately owned lands form the majority. They are located in the most densely settled and most fertile parts of the county, which are also nearest to main roads. Company-, state- and federal-owned lands are in the areas where natural conditions are least favourable. This group includes the Indian reservation, a large unbroken area on the county's northern boundary (cf. Appendix 1). Part of the state-owned lands were once in private ownership, but are now tax-forfeited. The situation for land ownership categories in 1967, however, corresponds largely to that of 1948 (Sandberg & Horn & Guilkey 1950, Appendix Map).

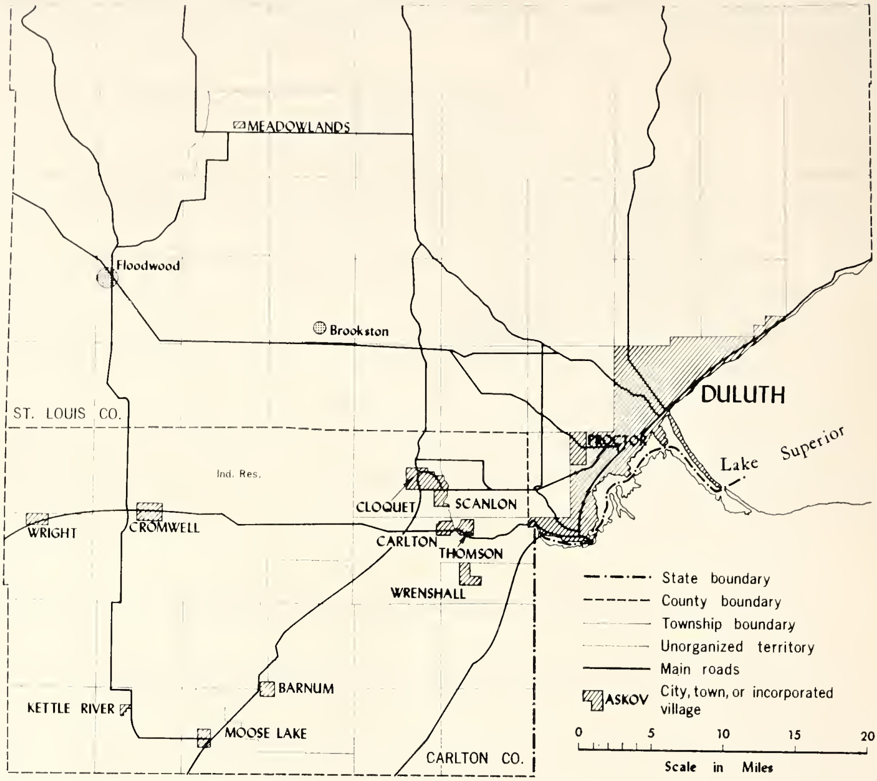

Fig. 2. Minor civil division and major roads in surroundings of Duluth.

The land ownership map indicates that company lands are few. They are forest areas owned by timber companies and banks for the most part, and have been used primarily in the same way as state lands. For this reason company and state lands are linked together in the present study. For two owner groups it is thus possible to form three boundary types according to the ownership categories between which the boundaries lie:

A. Private/private.
B. Private/company-county-state-federal.
C. Company-county-state-federal/company-county-state-federal.

These abbreviated boundary types are used for analysis in the present study.

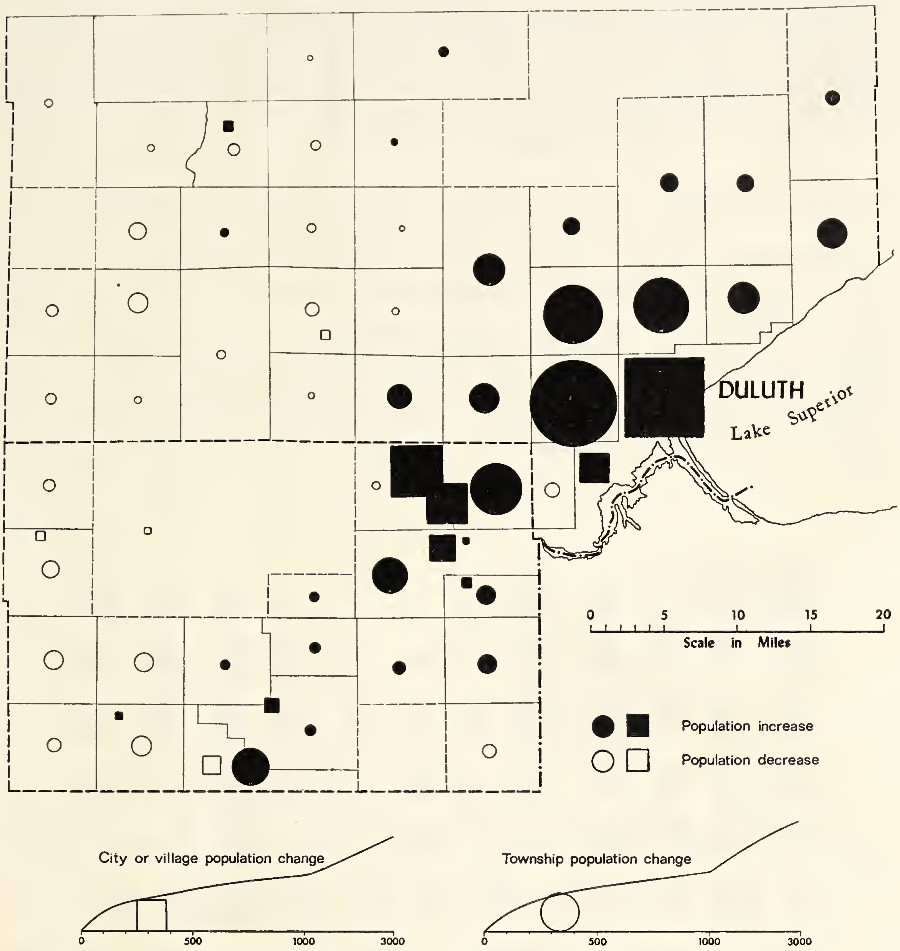

Fig. 3. Population changes in surroundings of Duluth: 1950—1960.

B. *Types of boundary change*

By comparing two source maps of different age it is possible to see changes which have occurred in boundaries. Two main types can be distinguished:

1) A new boundary has arisen.
2) The old boundary has disappeared.

Study of boundary changes makes it possible, moreover, to observe conditions of ownership as follows: changes are classified more precisely by examining the nature of the owner groups between which the boundary has disappeared or been extended.

C. How boundary changes depict changes of size in ownership areas

Boundary changes may naturally be a subject for study in themselves, but they acquire wider significance when it is noted that they reflect changes in complete landed properties. This study will now attempt a mainly theoretical consideration of how boundary changes are reflected in the size of properties. This will facilitate the adoption of a correct attitude to the analysis of boundary changes which is given later.

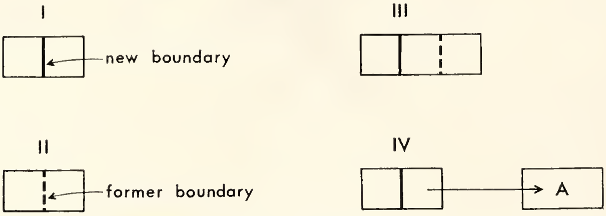

Fig. 4. Examples of the effect which the disappearance of an old boundary or the emergence of a new one may have on the size of a property.

The adjacent Fig. 4 shows certain oft-repeated cases in the study area as an example of the effect the disappearance of an old boundary or the emergence of a new one may have on the size of a property. In Type I a new boundary has caused one tract of land to be divided into two smaller ones. In Type II disappearance of a boundary has caused the merging of two small areas of ownership into one larger. In Type III emergence of a new and disappearance of an old boundary have not changed the number of ownership units, which remains two, but have altered their size relation. A new boundary generally reduces the size of ownership areas and increases their number, while disappearance of an old boundary increases the size and reduces the number. There are exceptions, however, as in Case IV: a new boundary has formed two separate parcels of land, but one of these has been bought as an addition to an already existing farm A.

On the whole, therefore, direct conclusions cannot be drawn on changes in the size of a property from the emergence of new boundaries and the disappearance of old. On the other hand, changes in the boundaries of ownership may be taken as a direct reflection of the extent of change activity in the area. The later part of this study will examine more closely the indicative value which boundary changes may have in the illustration of urban growth.

III. BOUNDARY CHANGES 1957—1967

A. *Total boundary changes*

When examining boundary changes the *length of boundary lines*[1] may be used as a measure. In 1957 the study area contained 3 371.2 miles of boundary all told. Length of boundaries in terms of quarter townships (3 × 3 miles) is shown in adjacent Fig. 5. Most boundaries are in the areas of closest settlement under private ownership in the close sphere of influence of Duluth and Cloquet and along the highway

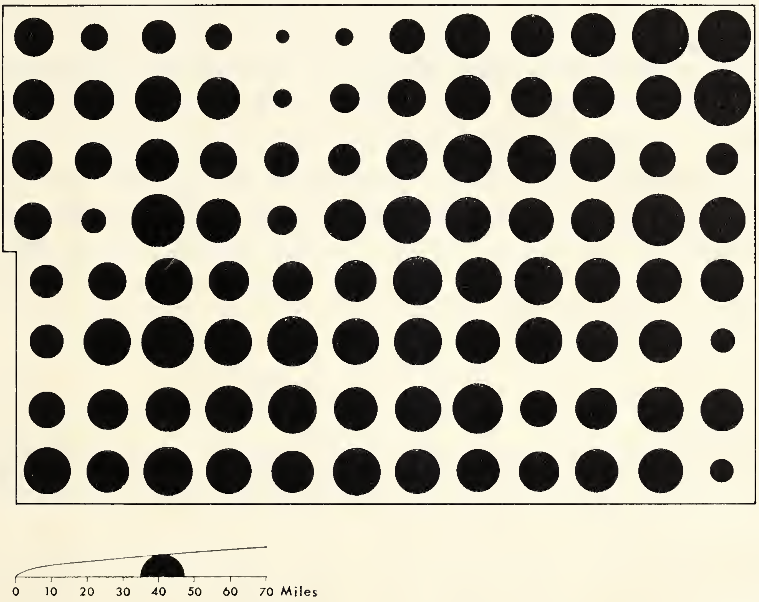

Fig. 5. Total length of boundaries by quarter townships (3 x 3 miles) in 1957.

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[1] In measuring boundary lengths »small tracts» are a difficulty. It is estimated that the perimeter of small tract areas corresponds to the length of boundary changes. Changes at the county boundary are disregarded because of lack of information.

leading to Twin City (cf. Appendix 1). The least number of boundaries is in the Indian reservation area.

During the study period boundaries increased by 172.5 miles, reaching a total of 3 533.3 in 1967. When examined in terms of quarter townships it is apparent that over most of the county there has been more emergence of new boundaries than disappearance of old (Fig. 6).

For the quantitative assessment of boundary changes the length of boundary lines was used as a measure. In some cases the line may be of great length although it has been determined by a single land deal. In other cases boundaries are very short, having arisen from the formation of small plots. For this reason the present study has made experimental use of a *unit of boundary* change in addition to boundary length as a means of measuring changes. This unit is defined as a boundary pattern, a line which may be straight or winding, but which is always unbroken. A twenty-yard boundary and a winding, branching boundary line a mile long are equally valid as boundary units.

Table 1 shows changes in boundary types measured both as length of boundaries and as units of boundary change. It is apparent that 380.8 miles of new boundary have emerged during this period, while 208.3 miles of former boundary have disappeared. Total boundary length has therefore increased by 172.5 miles. Measured as units of boundary change, the change is similar. Units arising from new boundaries are 160 more in number than those formed by boundaries which have disappeared.

TABLE 1. *Boundary changes in Carlton County in the period 1957—67.*

Boundary increases:	Length of boundary	Units of boundary
Private/private	170.9 miles	351 units
Others	209.9 miles	331 units
Total	380.8 miles	682 units
Boundary reductions:		
Private/private	97.2 miles	268 units
Others	111.1 miles	254 units
Total	208.3 miles	522 units
Boundary changes:		
Private/private	+ 73.7 miles	+ 83 units
Others	+ 98.8 miles	+ 77 units
Total change	+172.5 miles	+160 units

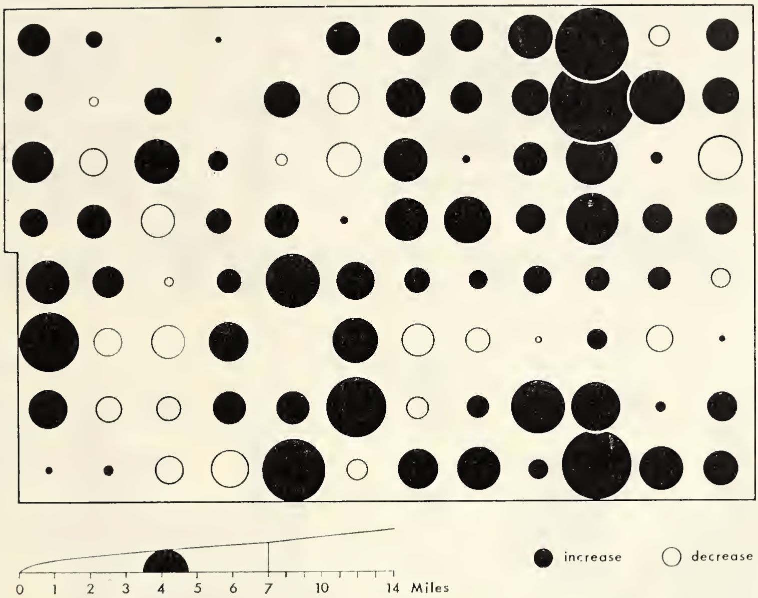

Fig. 6. Changes in total length of boundaries: 1957—1967. Scale ten times that of Fig. 5.

On the whole, total boundary changes in terms of quarter townships present a highly variegated regional picture (Fig. 6). A better starting-point for elucidation of regional changes is the scrutiny of boundary changes in terms of boundary types.

B. *Changes by boundary types*

Boundary changes in the period 1957—1967 are shown by types in four appended maps (Appendices 3—6). Appendix 3 contains boundaries which have arisen between private lands, while in Appendix 5 other boundary additions are found. Among boundaries between private lands many have arisen near each other. These are marked as »small tracts» in the 1967 Plat Book. They are shown in black in Appendix 3 because boundaries cannot be distinguished on the source map. Boundaries between private lands which have disappeared during the study period are shown in Appendix 4, and other vanished boundaries in Appendix 6.

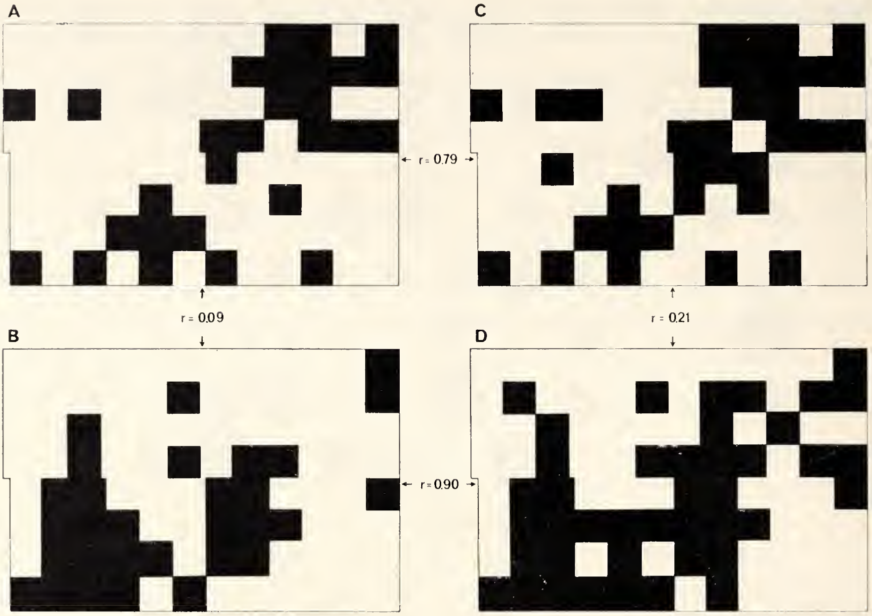

Fig. 7. Changes in boundaries between private lands in terms of quarter townships: 1957—1967. In black areas the change is more than county average.

A = increase in length of boundaries
B = decrease in length of boundaries
C = increase in number of boundary units
D = decrease in number of boundary units

Linear correlations (*r*) between different boundary change types are marked between maps.

a. Boundaries between private lands

During the study period 170.9 miles of new boundary appeared between private lands, while 97.2 miles of such boundary disappeared (Table 1). From appended maps 3 and 4 visual conclusions can be drawn as to the regional distribution of these boundary changes. Fig. 7 also shows by quarter townships the areas which contain more than the average of each boundary type. Whether shown as length of boundary changes or as units of boundary change, the changes are quite similar. Divisions illustrating an addition of boundaries in terms of quarter townships are statistically in high significant positive linear correlation, as are sketch maps showing a reduction of boundaries (Fig. 7).

The main part of new boundaries appearing between private lands are concentrated near Duluth and Cloquet and along the highway leading to Twin City in the neighbourhood of towns and villages. In the areas of greatest increase there are numerous small tracts. In most cases these reflect an expansion of one-family residential areas. Also included, however, are successive areas of holiday cottages which have sprung up on lake shores.

In the close neighbourhood of Duluth and Cloquet there are very few boundary reductions compared with additions (cf. also Appendices 3 and 4). As the distance from these cities increases, the number of reductions compared with additions grows. When examined in terms of quarter townships, however, this interrelation shows many exceptions, a fact revealed by the weak correlation between additions and reductions (Fig. 7).

It is clear that boundary changes depend greatly on the number of boundaries existing in each area at the beginning of the study period. In other words it cannot be assumed that in an area which in 1957 contained only one boundary, more than this number could have been destroyed. For purposes of closer analysis, therefore, boundary changes should be brought into relation with the total number of boundaries in 1957.

Fig. 8 shows additions and reductions of the length of boundaries between private lands in terms of quarter townships as percentages of all boundaries in 1957. The general picture is similar to that afforded by absolute boundary changes. In the neighbourhood of

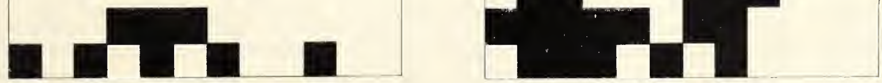

Fig. 8. Change in length of boundaries between private lands as percentages of all boundaries: 1957—1967. In black areas the change is more than county average.

E = increase in length of boundaries
F = decrease in length of boundaries

Duluth and Cloquet additions are relatively at their greatest, but reductions are below average. Boundary additions are also relatively numerous around the town of Moose Lake. Boundary reductions are relatively most numerous in the south-western half of the county. Between the relative additions and reductions there is no linear correlation ($r = 0.02$).

b. Other boundaries

During the study period 98.8 more miles of boundary appeared than disappeared between other than private lands (»Others» in Table 1).

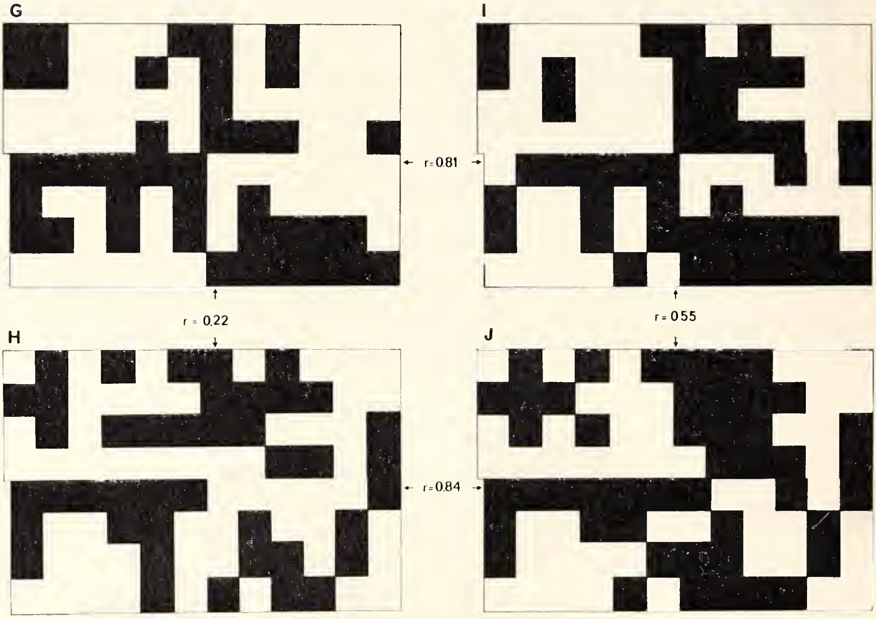

Fig. 9. Changes in boundaries between other than privately-owned lands in terms of quarter townships: 1957—1967. In black areas the change is more than county average.

G = increase in length of boundaries
H = decrease in length of boundaries
I = increase in number of boundary units
J = decrease in number of boundary units

Linear correlation (r) between different boundary change types are marked between maps.

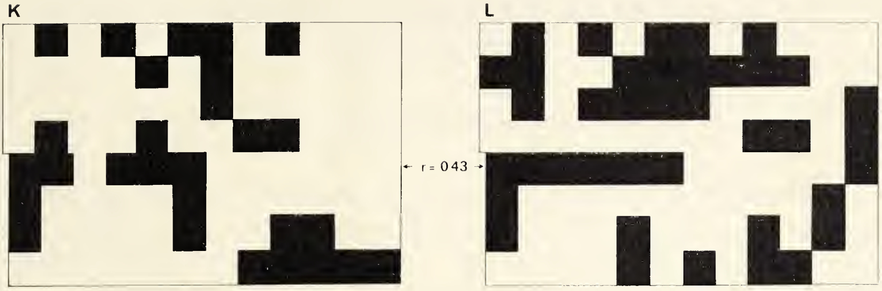

Fig. 10. Changes in length of boundaries between other than private lands as percentages of all boundaries: 1957—1967. In black areas the change is more than county average.

K = increase in length of boundaries
L = decrease in length of boundaries

In a spatial sense the new boundaries are located regularly in areas where other than private lands occur (Appendices 2 and 5). The most striking fact is that many new boundary units are of great length, which means that deals in land have embraced greater territories than in private areas. This is understandable because federal and similar lands are mostly areas of swampy forest. Examined in terms of quarter townships, boundary additions, whether counted as length units or boundary units, are statistically in a significant positive correlation (Fig. 9), i.e. they illustrate the same thing.

In general, vanished boundaries are located in the same districts as boundary additions. Counted in terms of quarter townships, additions and reductions of boundary units are statistically in a significant positive correlation ($r = 0.55$).

When additions and reductions are calculated as a proportion of all boundaries, the same features are revealed as in absolute boundary changes (Fig. 10). Between relative additions and reductions there is a positive correlation ($r = 0.43$) which is statistically significant at 0.1 % level.

On the whole, boundary changes between federal and similar lands do not appear to illustrate changes in the urban-rural fringe as clearly as changes between private lands. Boundary changes between federal and similar lands seem to follow a mosaic of regional patterns, while changes between private lands seem to group themselves in zones around both large and small centres. These visually noted conformities will now be tested more closely.

IV. RELATION OF BOUNDARY CHANGES TO URBAN GROWTH ZONES

A. Boundary changes and distance from the city

The foregoing visual examination of boundary changes revealed a possible dependence between certain types of boundary change and distance measured from the city. In order to clarify this matter distances were calculated from Duluth along the shortest main road to the centre of each township.[1] Ratios affecting boundary changes were also calculated, using the township as a unit. Statistical data for townships are available from the census, which justifies this choice of a regional unit.

Both absolute and relative additions to boundaries between private lands are in clear negative linear correlation with distance (correlation significant at almost 1 % level — Table 2). The next greatest correlation is between distance and new boundaries separating federal and similar lands. The positive correlation, however, is not quite significant at 5 % level. Correlation analysis therefore supports the visual observations made earlier.

TABLE 2. *Linear correlation between types of boundary change and distance measured from Duluth, calculated by townships.*

Boundaries between private lands	Absol. addition	— 0.56 *
	Relat. addition	— 0.57 *
	Absol. reduction	0.31
	Relat. reduction	0.33
Other boundaries	Absol. addition	0.46
	Relat. addition	0.47
	Absol. reduction	— 0.12
	Relat. reduction	0.25

* sign. at 5 ⁰/₀ level

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[1] To measure the distance from the centre for the different areas involved »General Highway Maps» and »County Maps» have been utilized. The distance has been measured from the geometric centre of the township to the boundary of Duluth or Cloquet. The figure is related to either Duluth or Cloquet, depending upon which city is closer to the township or village. The method is the same as in previous studies of the area made by the author (Rikkinen 1968, p. 317; Rikkinen and Alanen 1969, p. 61).

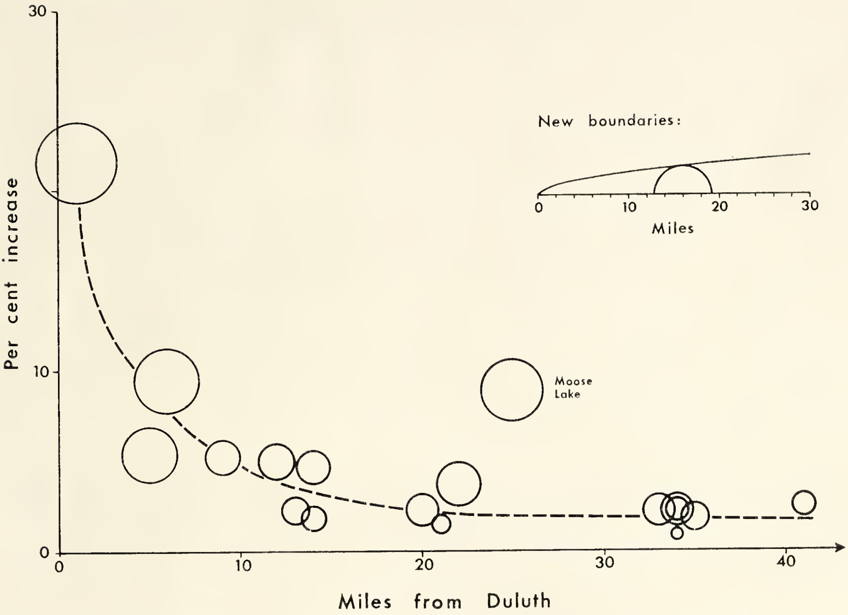

Fig. 11. Relationship between addition of new boundaries between private lands and distance from Duluth, by townships.

The linear correlation of distance and types of boundary change, however, is only a rough measure of the relationship between these variables. A better picture of the dependence is obtained from the scatter diagram. Scatter diagrams were made of the relationship between all types of boundary change and distance. The most interesting proved to be the relationship between distance and boundaries separating private lands. Fig. 11 shows that these variables are not in linear but in curvilinear correlation. The boundary additions nearest Duluth and Cloquet are large. Reduction is swift at about 10 miles distance, after which boundary additions gradually decrease as distance increases. Separated from this general relationship as a residual is the township of Moose Lake, where settlement of suburban character has grown around a town of some 1 500 inhabitants.

Other scatter diagrams which were made gave no additional data of importance and are therefore not published.

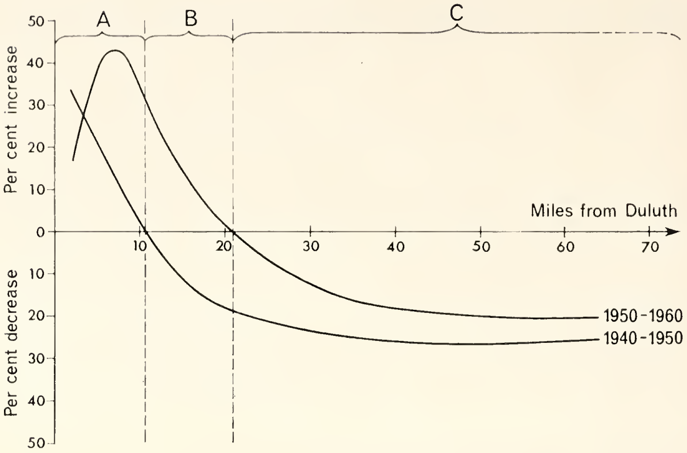

Fig. 12. Curves indicating average population changes by townships during the decades of 1940—50 and 1950—60 as a function of the distance from Duluth (after Rikkinen 1968, Figs. 6 and 9).

B. Boundary and population changes

In an earlier study population changes were explained as a function of distance measured from Duluth (Rikkinen 1968). In the decades 1940—50 and 1950—60 three zones of population development can be distinguished (Fig. 12):

A. Within a radius of about 10 miles from Duluth the population grew during both decades.

B. Between about 10 and 20 miles the population decreased in 1940—50 but increased in 1950—60.

C. In the outermost zone the population decreased during both decades.

In the decade 1940—50 the population change curve strongly resembles the curve in Fig. 11. The largest settlement, Moose Lake, deviates from the general relationship. The addition of new boundaries between private lands and the population change in 1940—50 are statistically in a highly significant positive correlation (Table 3).

On the whole, new boundaries between private lands appear to represent a boundary type in which such factors as population changes and distance from the centre, which are otherwise descriptive of a

TABLE 3. *Linear correlation between boundary and population change, calculated by townships.*

Boundary type	Boundary change	Population change 1940—50	Population change 1950—60
Boundaries between private lands	Absol. addition	0.79***	0.33
	Relat. addition	0.74**	0.22
	Absol. reduction	— 0.28	0.02
	Relat. reduction	— 0.36	— 0.08
Other boundaries	Absol. addition	— 0.10	— 0.54*
	Relat. addition	— 0.66**	— 0.18
	Absol. reduction	0.26	— 0.07
	Relat. reduction	— 0.31	— 0.06

* sign. at 5 % level
** sign. at 1 % level
*** sign. at 0.1 % level

rural-urban fringe zone, appear most clearly. With other boundary types spatial changes have more of a mosaic pattern.

C. *Two case areas*

It has previously emerged that trends of boundary change in the zone nearest Duluth are different from those at a greater distance. Typical features at detail level will be presented of two areas, one in Zone A, the other in Zone C (Fig. 12).

The *Esko* area is located in the township of Thompson along the road between Duluth and Cloquet (Appendix 1). Fig. 13 shows its growth of settlement in the period 1939—66. To some extent this growth has scattered, though mostly in fixed groups. Thus the small tracts have been formed which are typical of this zone (Appendix 2). The area used to be one of almost purely agricultural settlement with fields in effective use (Mattinen 1939). Since it passed into the suburban zone, wide expanses are no longer cultivated. The fields which have been longest without cultivation are covered with bush. It is interesting to note that boundary lines give perhaps the most sensitive perception of land use changes. Further evidence of this is clearly seen in air photographs (Fig 14), which can be used with good effect in rough analysis of boundaries.

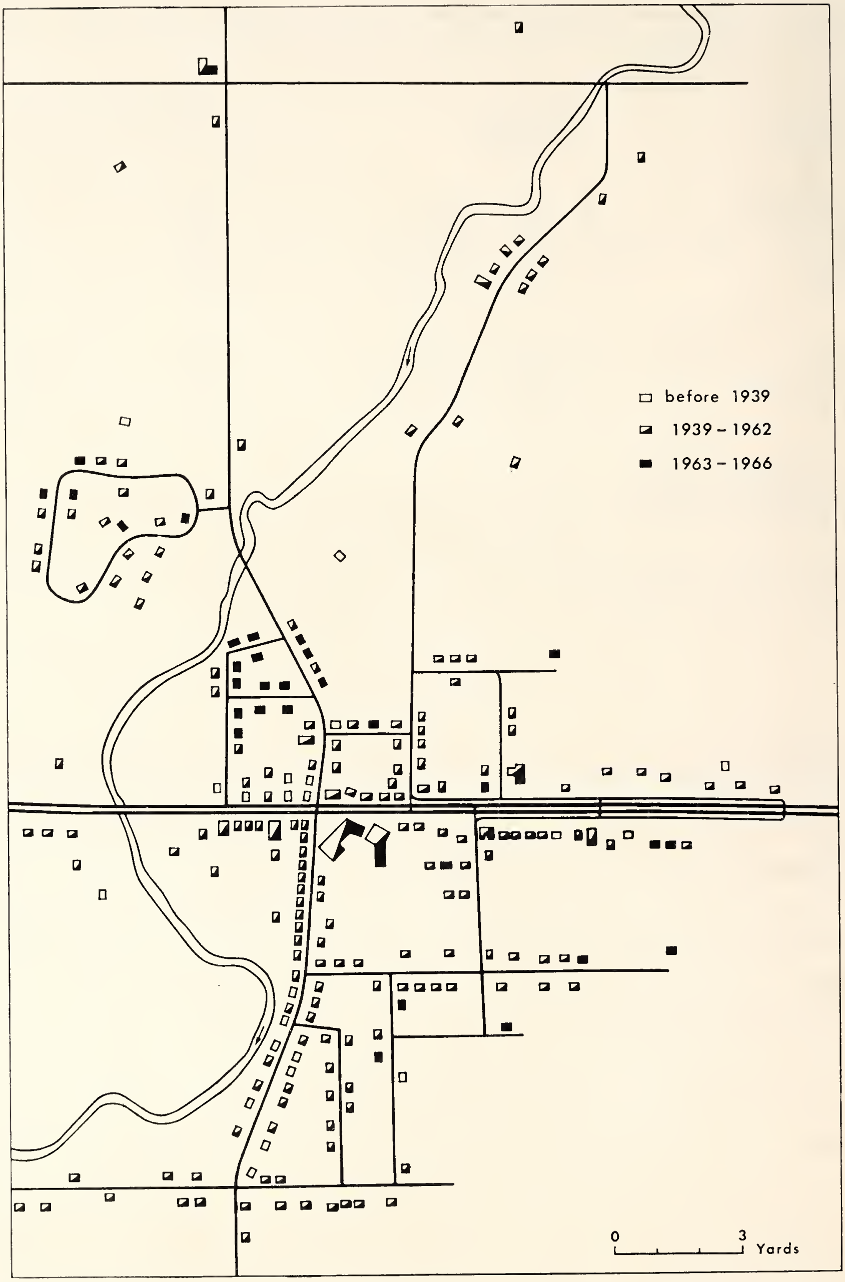

Fig. 13. Growth of settlement in Esko during the period 1939—1966. Sources: Air photographs 1939, 1962 and field work 1966.

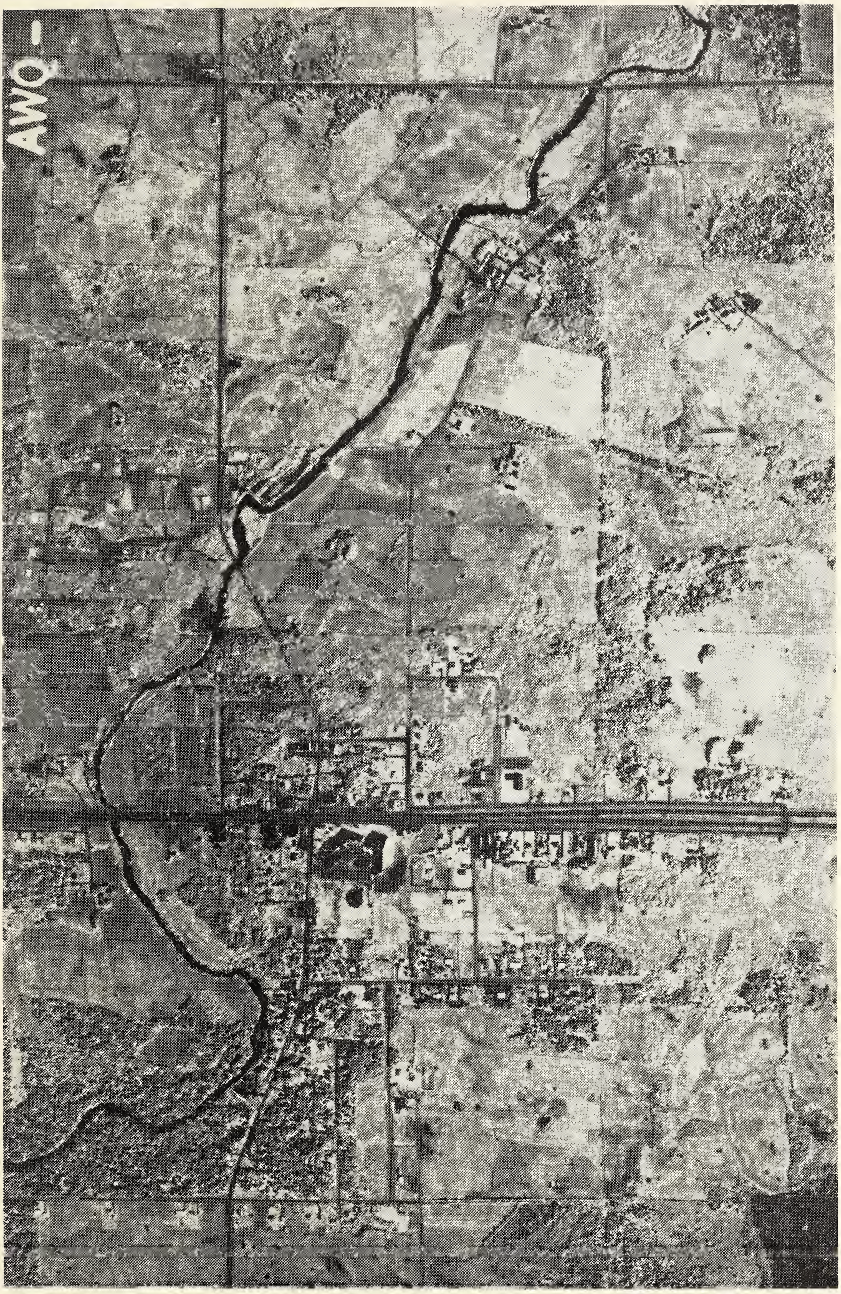

Fig. 14. Air photograph of Esko (13. 8. 1962). Fields and bush stand out in the picture. Fields are bush-covered especially in areas where new suburban settlement has arisen (cf. Fig. 13). As fields begin to lose their agricultural significance, bush growth starts generally on the boundaries of units of ownership. Thus many boundaries stand out in the air photograph as narrow zones more thickly bushed than their surroundings.

Kalevala township is located in Zone C of population change. Agricultural development in terms of the area's farms has been studied earlier (Rikkinen 1969). With reference to the material of previous study it may be noted that the 1940s were a period of vigorous »flight from the land»: 1) old boundaries disappeared mainly from swamp and forest areas, where many small farms vanished altogether and lands were tax-forfeited; 2) new boundaries appeared mostly in the southern part of the township, nearest the village of Kettle River, where lands were divided into residential plots for the commuting population; 3) boundary changes were few in the great field areas along the main road, where large farms held their position.

In the 1950s the greatest boundary changes occurred even in areas which were most unfavourable to agriculture. A large proportion of lands lost to the state in the 1940s returned to private ownership, a fact which can be seen in boundary changes.

In the period 1960—66 boundary changes remained few in the best agricultural areas. Deals in land were still most prevalent in marginal areas. Boundary changes reveal, among other matters, that cheap federal lands were bought frequently for hunting camps.

On the whole, boundary changes in the Kalevala case area have always been greatest in the territories least favourable to agriculture. On the other hand, the best agricultural areas have remained steadily in the hands of the biggest farms, and boundary changes have been relatively few.

V. FINAL STATEMENT

The main result of this study may be found in its presentation of an idea. Examples have been given of how analysis of changes in boundaries of ownership may be used to illustrate changes in an urban growth zone. Boundary changes may be extremely accurate in such illustration. Changes can be noted quickly from maps and air photographs, and are quantitatively measurable. A further advantage is that the study of boundaries enables changes to be explained in terms of small areas, which is often impossible through published census data.

On the basis of this study an addition of boundaries between private lands appears to have special indicative value, as reflected in the growth of surburban settlement. Boundary changes between federal, state and company lands in turn illustrate accurately the changing use of »cheap land» in a peripheral zone.

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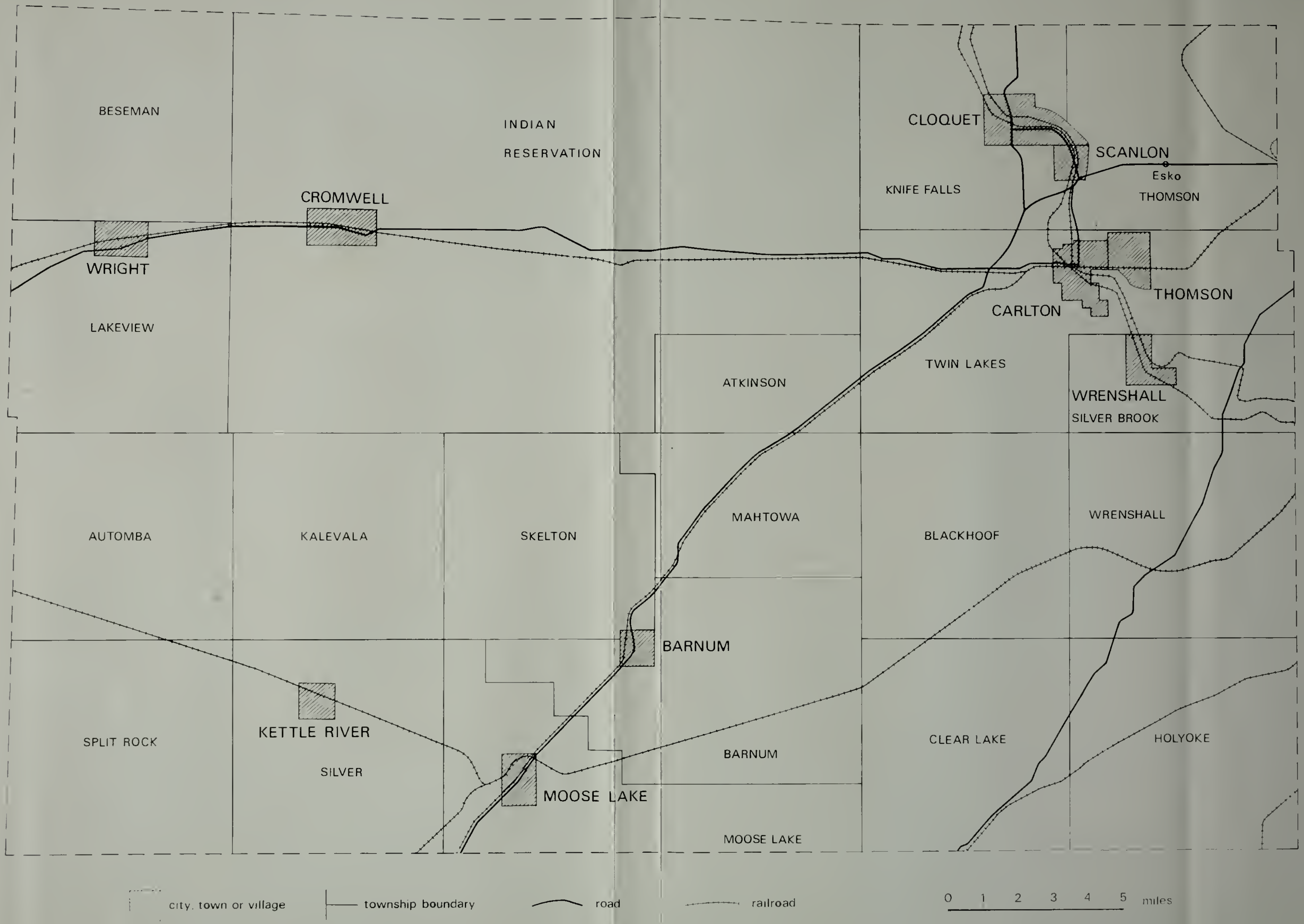
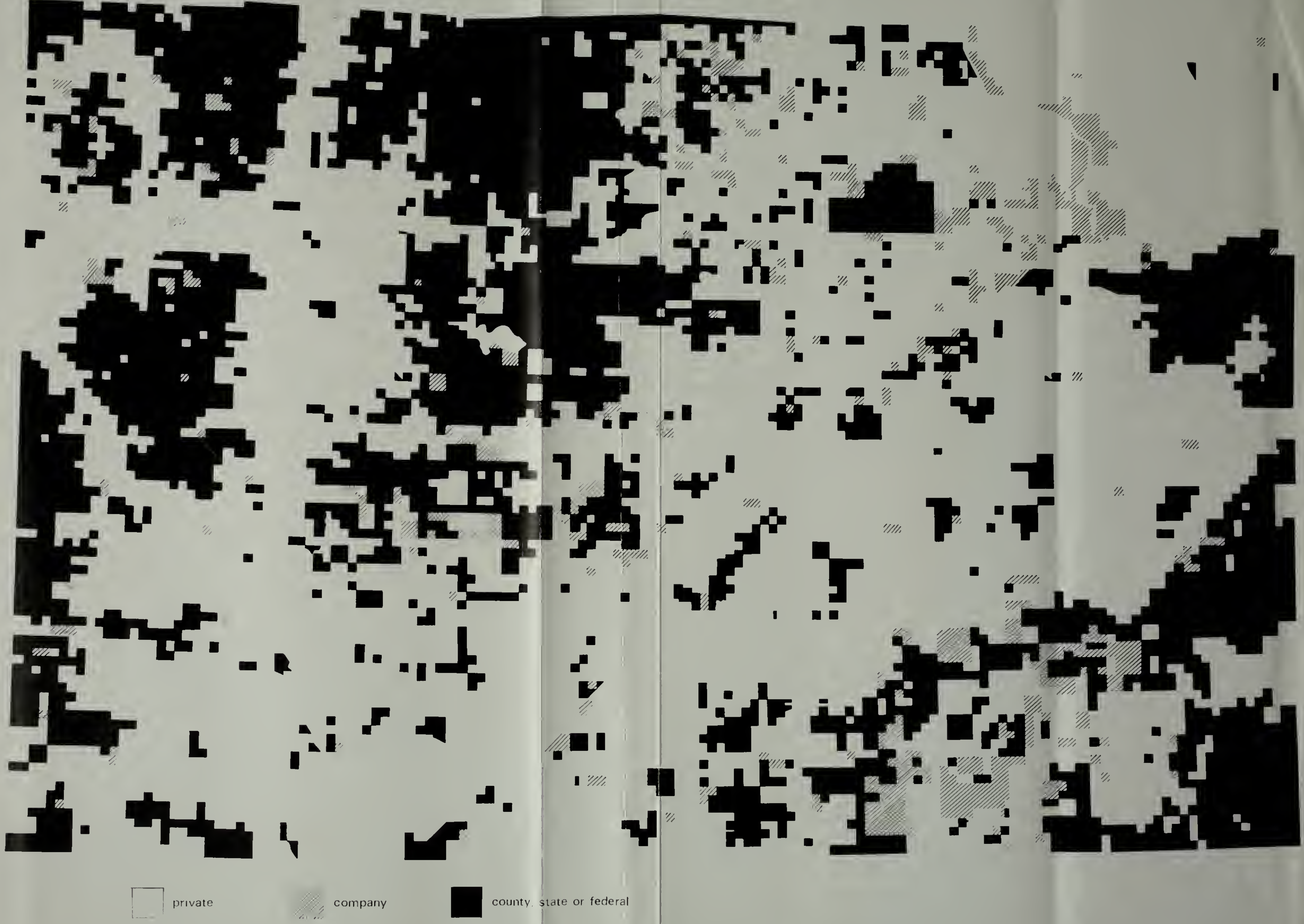
APPENDIX 1.

Minor civil divisions and major roads of Carlton County.



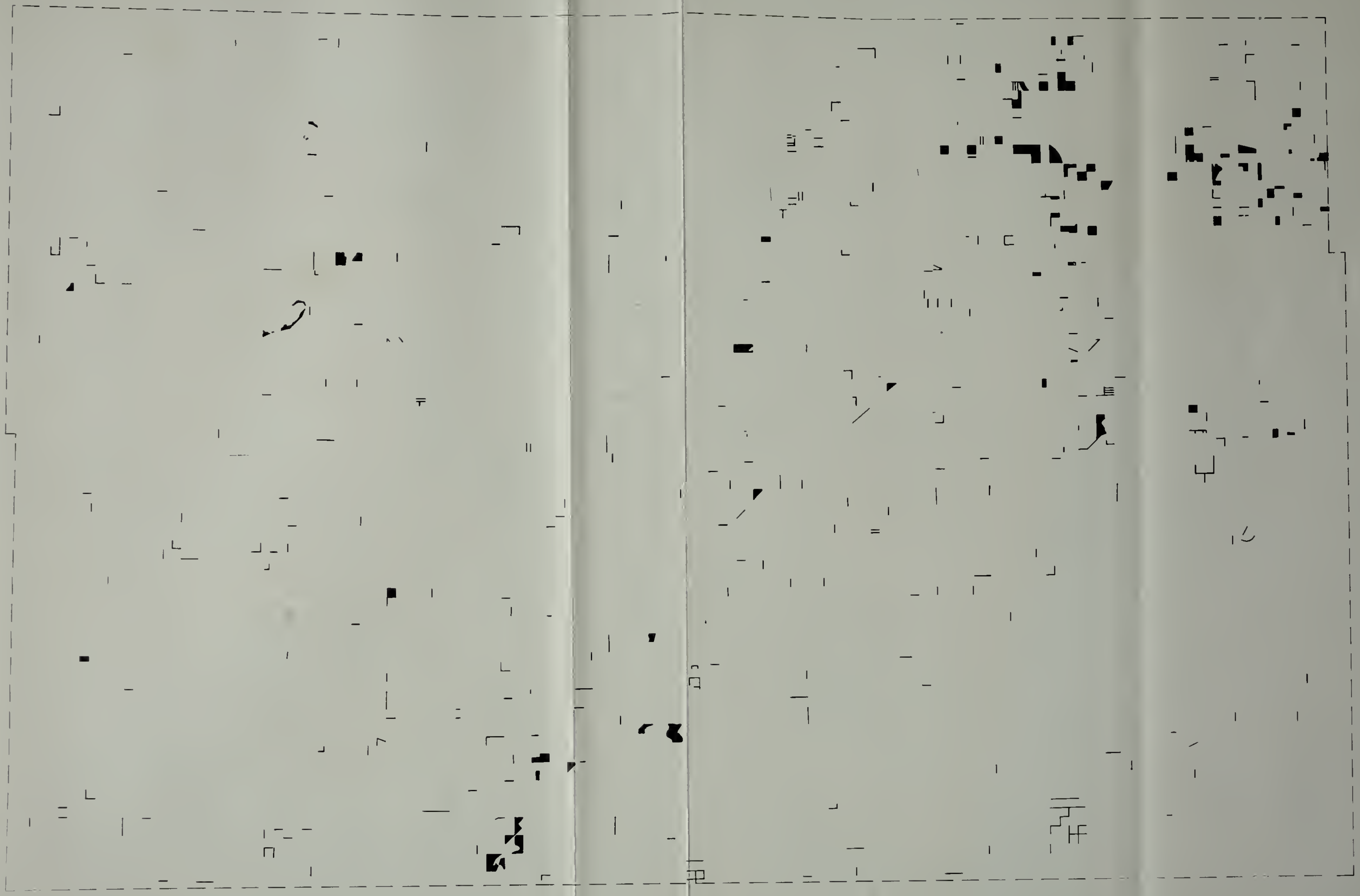
APPENDIX 2.

Land ownership map in 1967. Scale same as in Appendix 1.



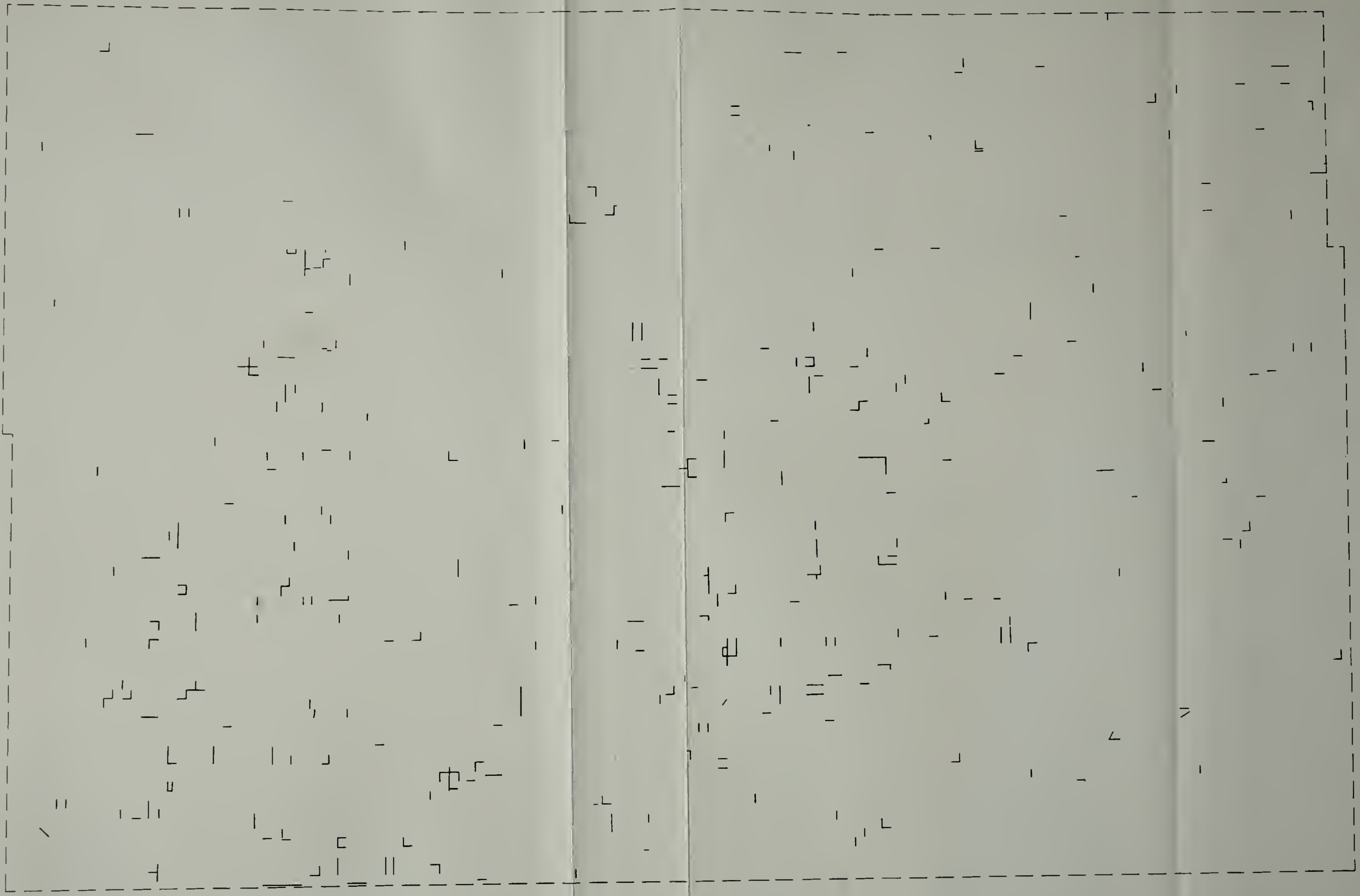
APPENDIX 3.

New boundaries between private lands: 1957—1967. The black areas are »small tracts» where many boundaries have arisen near each other. Scale same as in Appendix 1.



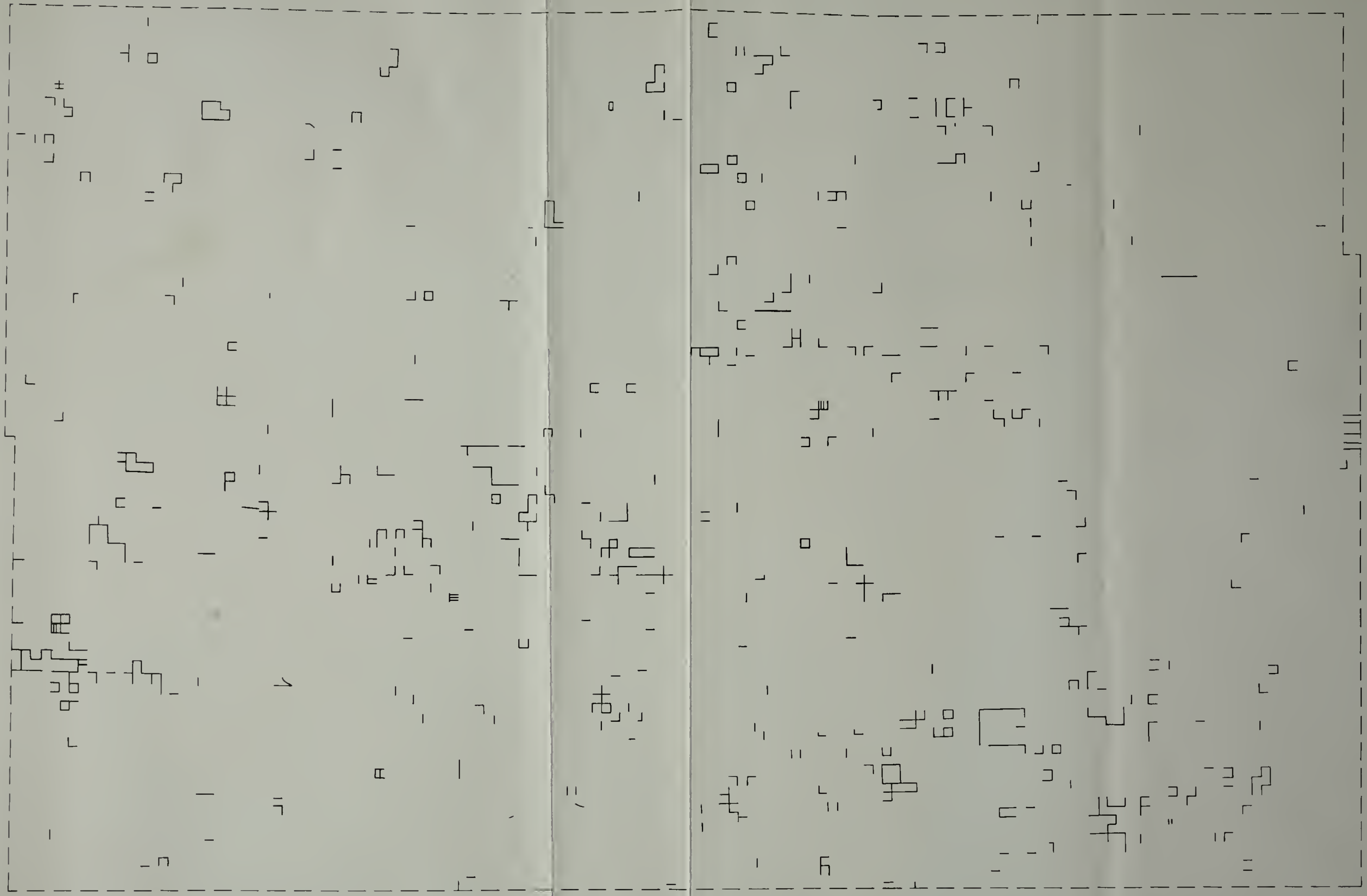
APPENDIX 4.

Boundaries disappeared between private lands: 1957—1967. Scale same as in Appendix 1.

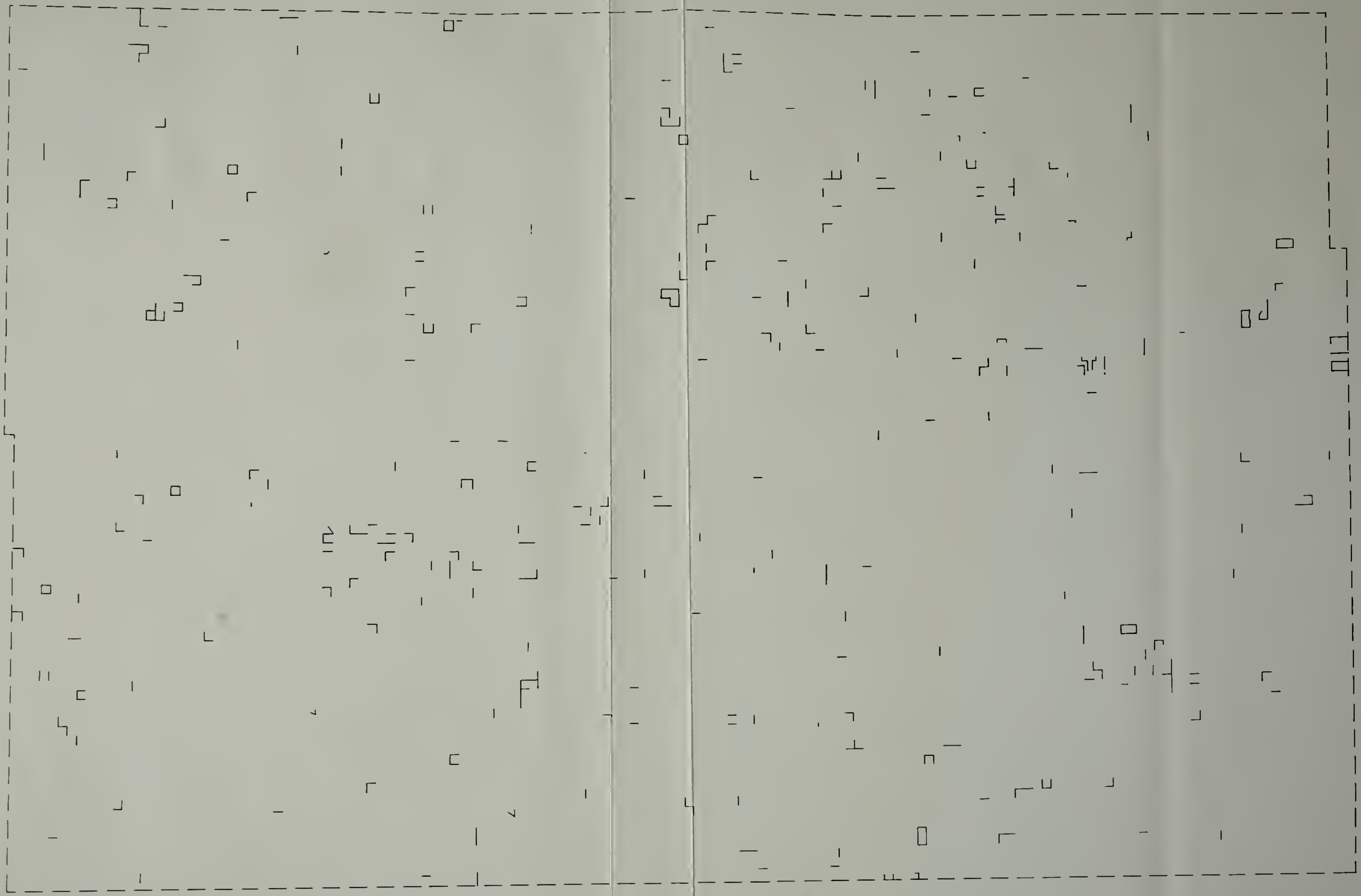


APPENDIX 5.

New boundaries between other than privately-owned lands: 1957—1967. Scale same as in Appendix 1.



Boundaries disappeared between other than privately-owned lands: 1957—1967.
Scale same as in Appendix 1.



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